Monsoon Disturbances Over Southeast and East Asia and the Adjacent Seas

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Award # N0001405WR20309

LONG TERM GOALS

To study weather disturbances over the East Asian – Western Pacific monsoon region and vicinity using Navy and NCEP operational analysis and forecast models. The primary goal is to advance the understanding of the weather-producing systems in the region, in order to improve forecast capabilities.

OBJECTIVES

The objectives are: (1) to study the structure and the dynamic and thermodynamic properties of the weather systems in the vicinity of the Southeast and East Asian monsoon region that stretches from Indian Ocean to the tropical Pacific, including the South China Sea and Yellow Sea, which are of particular interest to naval operations; and (2) to study the ability and sensitivity of Navy operational numerical models in analyzing and predicting these disturbances.

APPROACH

Observational studies/Data analysis: Use archived gridded data from global NWP outputs (including NOGAPS and NCEP model analyses) and satellite data to determine the structure of mesoscale and synoptic disturbances in various local regions for the different seasons. Use composite and principal component approaches to perform statistical analysis of the data.

Modeling: Use dynamic and numerical models to study the interaction of western tropical Pacific monsoon circulation and synoptic tropical disturbances.

WORK COMPLETED

To continue previous research on the weather over Southeast Asia and Maritime Continent, we re-examined the South China Sea cold surge, which is one of the most dramatic weather events during the Asian winter monsoon. The cold surge at the southern coast of China has been used operationally as an upstream precursor for a severe event that may affect the equatorial Maritime Continent within one or two days. In this year we analyzed the surge cases occurring in December 2004 – January 2005.

Another work was on the possible relationship between western Pacific tropical cyclones and the teleconnection pattern over North Pacific. We used data set of 1951-2001 to examine the impacts of

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2005**	2. REPORT TYPE	3. DATES COVERED **00-00-2005 to 00-00-2005**

4. TITLE AND SUBTITLE **Monsoon Disturbances Over Southeast and East Asia and the Adjacent Seas**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School, Code MR/Cp,Department of Meteorology,Monterey,CA,93943**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
code 1 only

14. ABSTRACT
To study weather disturbances over the East Asian ? Western Pacific monsoon region and vicinity using Navy and NCEP operational analysis and forecast models. The primary goal is to advance the understanding of the weather-producing systems in the region, in order to improve forecast capabilities.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

variations in tropical cyclone frequency, intensity, and track in the western North Pacific on northern hemisphere summer climate through changes in teleconnection patterns.

RESULTS

The development of a cold surge typically starts with the buildup and subsequent southeastward extension or split of the surface high-pressure area. The center of the high may either move southeastward, or remain nearly stationary but with packets of cold air propagating eastward in conjunction with smaller high-pressure or anticyclonic centers. Changes of upper-tropospheric circulations over Siberia have long been recognized as precursors of cold surges. The best known change is a northwesterly flow in the vicinity of Lake Baikal that is associated with an upper-level wave, which precedes a surge over the southern coast of China by 1-2 days. When a short wave propagates into the quasi-stationary East Asian longwave trough near Japan, the intensification of the trough strengthens the northerly wind and almost simultaneously the cold surge arrives at the southern China coast (e.g., Boyle and Chen 1987; Ding 1994; Chan and Li 2004).

The above model describes a single cold surge event that evolves over a period of around one week. However, there are often consecutive signals of cold surges over the northern South China Sea with brief pauses of one or a few days between them such that the surges appear to be a series of sequential events.

The evolution of a series of two surges observed at the southern coast of China at the end of 2004 is shown in Fig. 1a (500 hPa geopotential height and wind speed) and Fig. 1b (sea-level pressure and surface temperature). The first case can be traced to 26 December 2004 (upper left panels in both figures) and involved a near-stationary Siberia-Mongolia High center and an eastward-moving, upper-level shortwave trough (S1) that started near Bangladesh and northeast India and had a minor jet streak to its south. Throughout the surge development, this shortwave did not interact significantly with the East Asian longwave trough to the north. The surge affected Hong Kong on 28 December 2004 with a large decrease of more than 6°C in daily-average surface temperature. However, the surface pressure increase was very modest and the surface moisture change was negligible. The second case can also be traced back to 26 December 2004, when a zonally-oriented 500 hPa trough (Z) north of Mongolia between 45°N-50°N, 80°E-110°E began to intensify and propagate southeastward. On 29 December 2004, another shortwave trough (S2) appeared in southern China just east of 105°E and propagated eastward. On 30 December the Z trough moved into the southwest quadrant of the East Asian longwave trough and became its southwest part. As a result, the longwave trough had a significant extension into southern China. The East Asian trough continued to deepen the next day and sweep counterclockwise so that it was joined by S2 near Taiwan. When the second surge passed Hong King on 31 December, a daily-averaged surface temperature drop of slightly less than 4°C was reported. Although the temperature decrease was smaller than with the first surge, it led to the lowest temperature of the season by then. This second event, which was associated with a deeper East Asian trough and a stronger upper-level jet streak, fits the “classic model” of a cold surge. In contrast to the first surge, the SIBERIA-MONGOLIA HIGH center moved southeastward toward the southeast coast of China and resulted in a sharp rise of the surface pressure and a sharp decrease in the dew-point temperature on 31 December 2004 at Hong Kong. The dryer air mass continued through the first few days of January 2005.

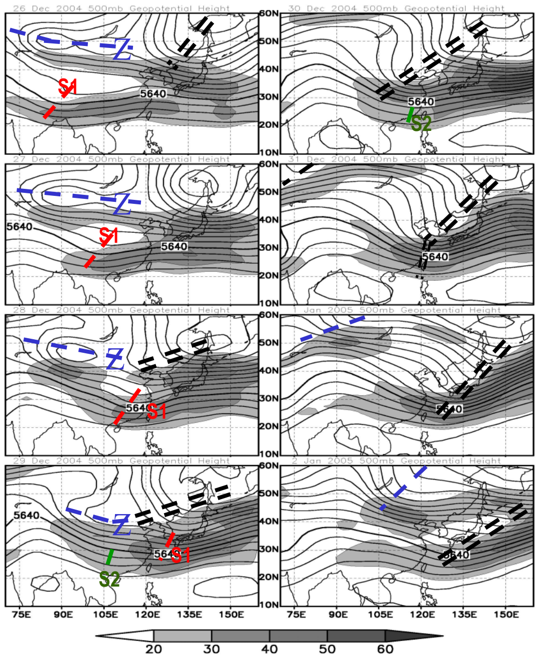
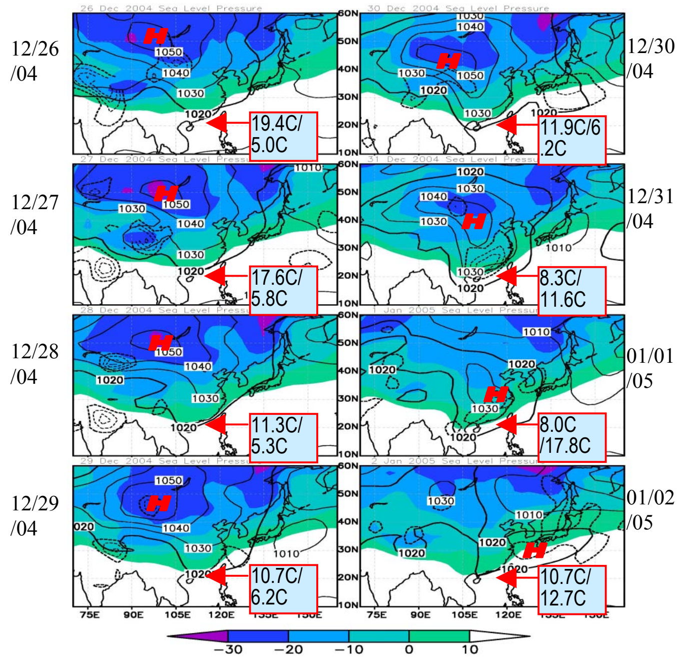


Fig. 1. a) Daily averaged 500 hPa geopotential height (contour intervals 60 m) and wind speed (shaded) for 26 December 2004 – 2 January 2005. Dashed lines indicate troughs, with Z the zonally elongated trough and S1 and S2 eastward propagating shortwave troughs. Double dashed lines indicate the East Asian trough.



b) Daily averaged sea-level pressure (isobars) and surface temperature (shaded) for 26 December 2004 – 2 January 2005. The Hong Kong surface temperature (T) and dew-point depression (DD) averaged between 00 and 12 GMT are given in the text box in each panel. The day-time group for each panel are marked on Fig. 1b only.

Figs. 1a-b show that the Siberia-Mongolia High and the East Asian longwave trough continued their southeastward and eastward movements, respectively, after the cold surge. On 31 December 2004, another shortwave trough appeared in the northwestern corner of the domain and moved to the eastern boundary of Mongolia on 2 January 2005, but it did not interact with the East Asian trough which had moved to the western North Pacific. No surge resulted from this event.

The tropical cyclone – teleconnection works revealed a significant correlation during active TC years between western North Pacific and North America. This relationship is independent of the influence of western Pacific SST's and ENSO. An analysis of 500 hPa mean winds showed weaker winds during active TC years, which, combined with our result of a stronger teleconnection pattern between NA1-P115 during active TC years, seems to substantiate Lau and Weng's (2000) Mode 1 (zonally-elongated) jet theory. It may be that the stronger teleconnection patterns observed here are the result of Lau and Weng's (2000) Mode 1 and not the presence of more TC's.

IMPACT

This study was a continuation of the work on Maritime Continent weather and winter monsoon interactions motivated by a Navy operational problem –Typhoon Vamei caused damages to USS Carl Vinson and an accompanying ship. The northeast monsoon surges with their strong winds are a main weather hazard for ships in the South China Sea.

RELATED PROJECTS

NSF Project on West Pacific Monsoon Dynamics at NPS.

SUMMARY

While the classic model of cold surges describes a substantial southeastward extension or split of the Siberia-Mongolia High at the surface that is associated with a high latitude upper level trough, there are often consecutive signals of cold surges over the northern South China Sea with brief pauses of one or a few days between them such that the surges appear to be a series of sequential events. It is shown that subtropical wave disturbances that originate from South Asia can also lead to cold surges in the South China Sea. However, the intensification of the upper-level East Asian trough and the eastward propagation of a jet streak are always important parts of the event.

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